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# Synergies and trade-offs between local and global ecosystem services in Costa Rica

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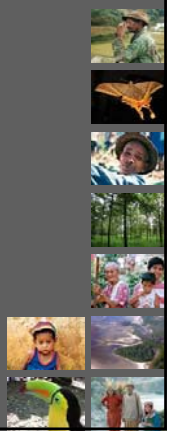


## Ecosystem Services: "The benefits people obtain from ecosystems"

Climate regulation
Water purification
Pollution control
Water regulation
Soil protection
Scenic beauty
Cultural heritage
Spiritual values
Pollination
Genetic resources
Wood
Food
Fuel and energy

# Introduction

- Economic instruments for conserving ES
  - Payment for Ecosystem Services (PES)
- Costa Rica
  - PES at the national scale
  - Mainly for forest conservation (91% of the area)
  - Four recognized ES:
    - Biodiversity conservation
    - Carbon sequestration
    - Hydrological services
    - Scenic beauty
  - No real targeting of payments




# How to target PES?

- Three factors (Naidoo et al., 2008)
  - Level of ES provision, depending on:
    1. ES production by ecosystems
    2. Use of ES by human populations where the ES flow
  - ES additionality, depending on:
    3. Risk of land use conversion
- Possible trade-offs:
  - E.g. for a given ES:
    - high level but low risk
  - For various ES
    - High level of provision of one ES but low level of the others

# Questions

Does the conservation of one ES contribute to the provision of the others?

Are there synergies between biodiversity, local services (water, scenic beauty) and global services (carbon)?

Are there areas with high level of provision of the four ES?



# Approach

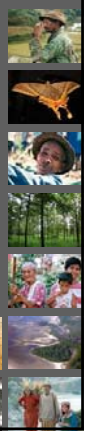
- Mapping at the national scale
  - Resolution: from 0.25 to 20 km
    - Clearer results with 4 km
- 4 maps:
  - Biodiversity
  - Carbon sequestration
  - Hydrological services
  - Scenic beauty

# Ecosystem service mapping: Overview

Level of ecosystem service

- Ecosystems: Production of ES by the ecosystem ("the factory")
- Humans: Presence of beneficiaries in the space where ES is delivered ("human well-being")

Flow of ES





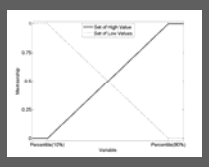
# Fuzzy logic

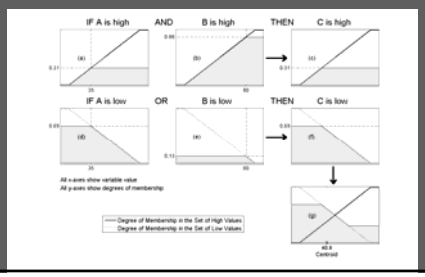
- Modeling with rules:
  - E.g. IF ( Production of ES by ecosystems is high) AND (Presence of humans benefiting from ES is HIGH) THEN (level of ES is high)

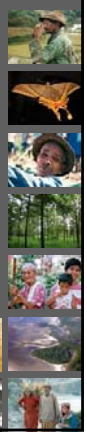
Data

Fuzzy rules: If A high and B high => C high
If A low and B low => C low

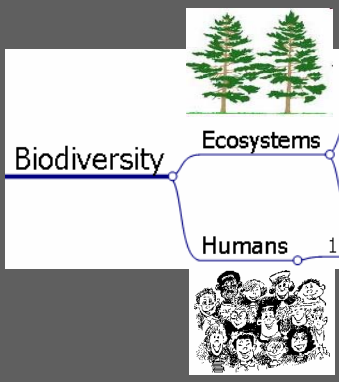
Fuzzification → Fuzzy inference → Defuzzification





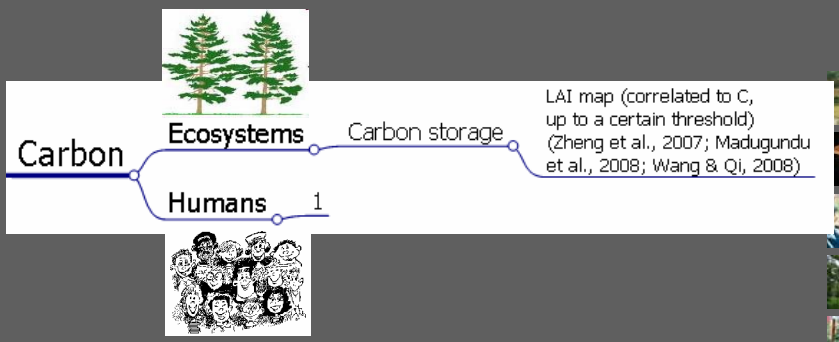



# Biodiversity





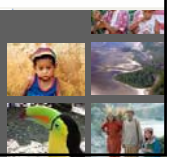

# Carbon



# Water

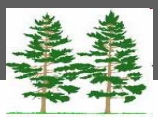
Water

- Ecosystems
  - Water quality
    - Erosion
      - Difference of erosion between forest and non forest
        - K (soil erodibility)
        - R (rain erosivity)
        - S (slope)
  - Water quantity
    - Water yield
      - horizontal interception minus evapotranspiration (Mulligan and Burke, 2005)
    - Water regularity
      - Soil infiltration capacity (FAO)
        - Soil texture
        - Soil depth
      - Effect of forest on infiltration (Ilstedt et al., 2006)
- Humans
  - Volume of water use downstream
    - Domestic
    - Agriculture
    - Energy



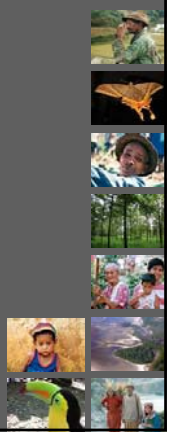


# Scenic Beauty

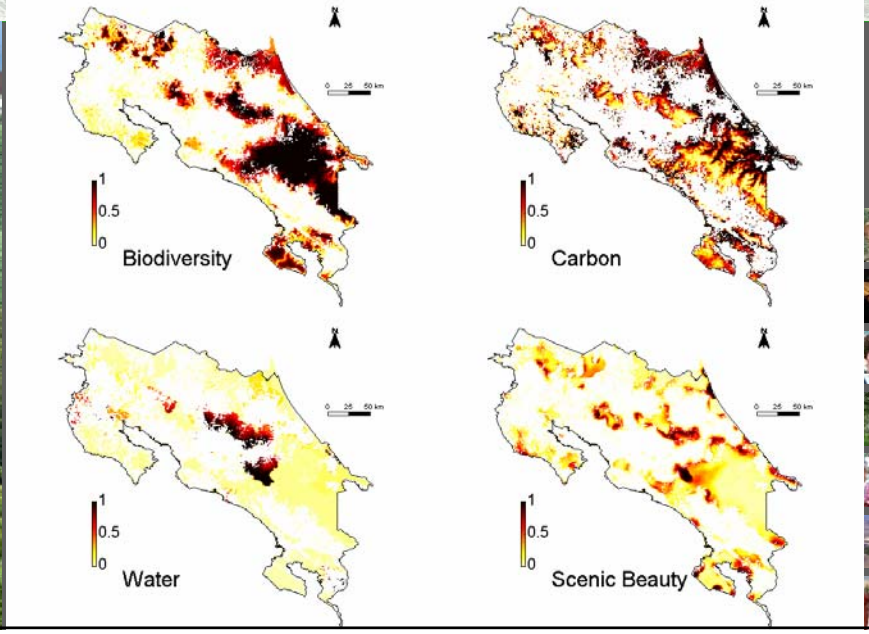


Scenic Beauty

- Ecosystems
  - Large patches of pristine forest areas (Biénabe and Hearne, 2006; Wunscher et al., 2008)
- Humans
  - Local people (population density in the surroundings)
  - Tourists
    - Hotel rooms in the surroundings
    - Tourist attractions in the surroundings



# Results and discussion






# Analyzing synergies

| | Low $ES_1$ | High $ES_1$ |
|---|---|---|
| Low $ES_2$ | | Trade-off |
| High $ES_2$ | Trade-off | Synergy |

Synergy Index =

$$\frac{\text{Area(synergy)}}{\text{Area(synergy)} + 0.5\ \text{Area(trade-off)}}$$

Synergy Index

0 → 1

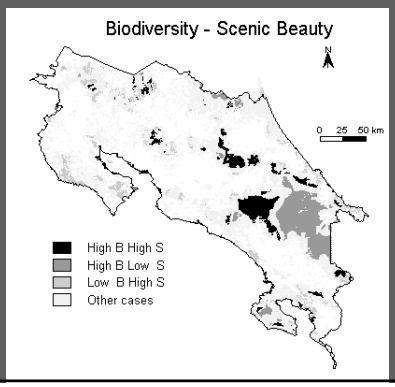
Full trade-off — Full synergy

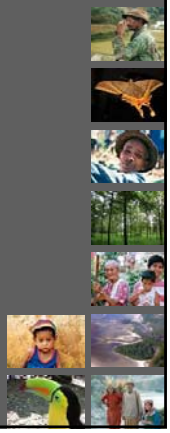
# Biodiversity-Scenic Beauty

Trade-off — Synergy

0.28

Most biodiversity hotspots are far from population or tourists



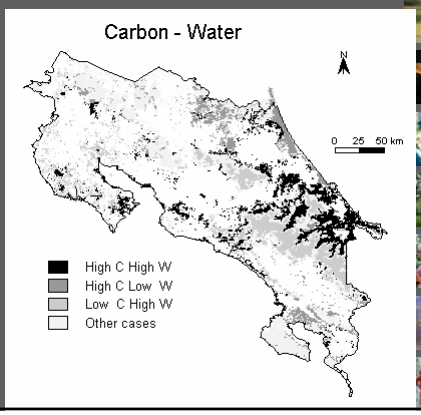


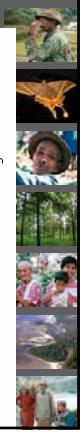
# Carbon and water

Trade-off — Synergy

0.41

More water hotspots in the mountains but more carbon in lowlands

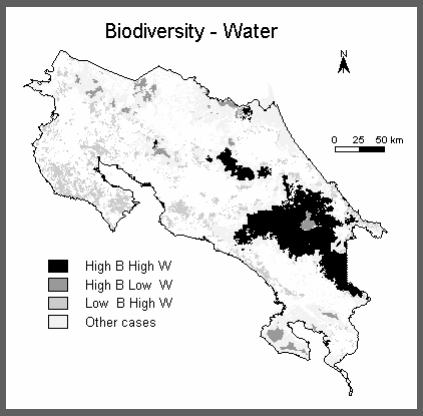


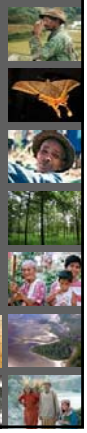
# Biodiversity and water

Trade-off — Synergy

0.74




Role of protected forests in the mountains, upstream of big cities

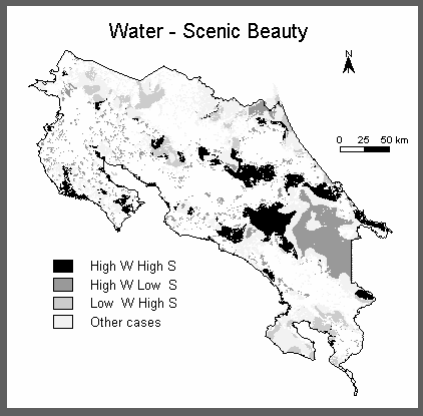




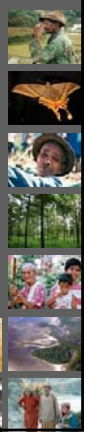
# Water and scenic beauty

Trade-off — Synergy

0.78

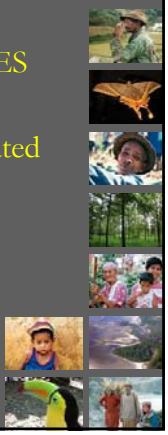



Large patch of protected forests near cities and tourist places provide both water services and scenic beauty



# Conclusion

- Synergies and tradeoffs:
  - Synergy between local services (water and scenic beauty)
  - Biodiversity conservation contributes to local services (water)
  - Prioritizing carbon may not favor local services
- Identification of hotspots for certain ES:
  - In the Costa Rican PES, many buyers of individual ES
- It is possible to identify hotspots of several ES:
  - Importance of protected forests upstream of populated places:
    - Water, biodiversity and scenic beauty at the same place



# Thank you!